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Grid to Vehicle and Vehicle to Grid (V_2G) Overview in the Smart Grid

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Abstract

The grid to vehicle context in this report referred to the current status of the vehicle charging system that supported by the grid and its implication to the grid. The electric vehicle also can be exploited and treated as the mobile energy storage that has the capability to inject the power back to the grid. The idea of transfer back power the grid from electric vehicle is commonly known as V_2G. In total, the cumulative horse power that millions vehicle have are tens times larger than the total of all electricity generating capacity in the world. However, due to the technical issue, the vehicle potential could not be tap to contribute to the grid until the birth of current concept of so called V_2G. V_2G is relatively a new technological breakthrough, which not only support the grid but also could potentially accelerate the process of creating a smarter grid.

Keywords: *Electric Vehicle, Smart Grid and V_2G*

Abstrak

Konteks grid to vehicle dalam laporan ini mengacu pada status terkini dari sistem pengisian kendaraan yang didukung oleh sistem kelistrikan dan implikasi yang ditimbulkan terhadap sistem kelistrikan. Kendaraan listrik juga bisa dimanfaatkan dan diperlakukan sebagai mobile energy storage yang memiliki kemampuan untuk menyuntikkan tenaga kembali ke grid. Gagasan untuk mentransfer kembali listrik dari kendaraan listrik umumnya dikenal sebagai Vehicle to Grid V_2G. Secara keseluruhan, daya kuda kumulatif yang dimiliki jutaan kendaraan puluhan kali lebih besar dari total semua kapasitas pembangkit listrik di dunia. Namun, karena masalah teknis, potensi kendaraan tidak bisa disadap untuk berkontribusi ke grid hingga lahirnya konsep terkini yang disebut V_2G. V_2G merupakan terobosan teknologi baru, yang tidak hanya mendukung grid namun juga berpotensi mempercepat proses pembuatan grid yang lebih cerdas

Kata kunci: *Kendaraan Listrik, Smart Grid dan V_2G*

1. Introduction

Transportation is one of the areas that mainly responsible for the greenhouse effect. Since almost three-quarter of the oil production consumes by the transportation sector. The current development of smart grid allowing high penetration of renewable energy generation push the world to electrify the means of transportation which known as the electric vehicle. In addition to that the rapid development of adjacent devices such as Advanced Metering Infrastructure, Home Area network and power electronic devices also support the current development of electric vehicle. However, introducing the new and very dynamic demand such as electric vehicle poses some operational issue to the utility and gives some implication to the grid. This Implication must be understood in advanced to support the success of electric vehicle penetration.

The fact shows that more than 90 precent of the time the light vehicle is just standby in the parking spot or garage. The cumulative energy of this entire light vehicle in the world is tens times larger from the entire generating unit that available in the world. Here the electric vehicle unfolded its benefit to allow the grid receive power from the energy that already store in its battery. The concept of storing back energy back to the grid is well known as the Vehicle-to-grid (V2G). V2G is relatively new technological breakthrough that allows bidirectional power flow in electric vehicle. There are lot of motivation of behind the V2G concept, it can support the grid, provide ancillary services, resource balancing, provide economical opportunities and many more. However, because of V2G is an evolving technology there a lot of technical and non-technical barrier that obstruct its implementation. Currently there are several pilot projects that has already launched across the globe to study more about the V2G technology.

2. Type of Electric Vehicle

The term of Electric vehicle (EV) is a general idea about the vehicle that uses electrical energy rather than oil as its main or secondary source of power. In order to gain more understanding about the interaction between EV and Grid or vice versa, it is important to know certain type of EV that already available in the market or will be release to the market in the near future. Electric vehicle classified into seven types in [1] with respect to its architecture.

1. Battery Electric Vehicle (BEV)

BEV perhaps is the simplest type of available EVs. It comprises of three main components: Firstly, electric battery as the storage energy, secondly, electric motor and a controller [1]. The general scheme of BEV is shown in figure 1.

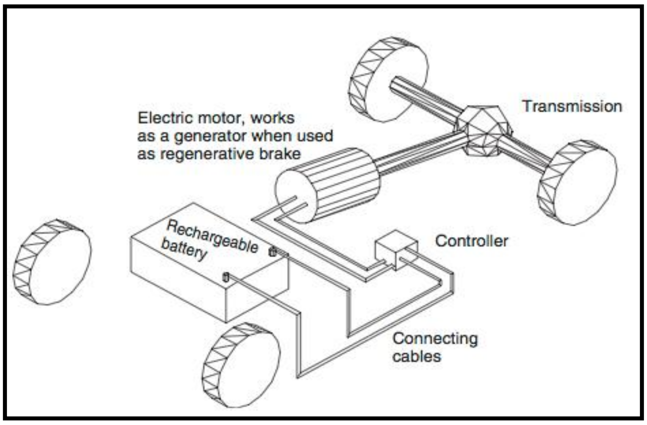


Figure 1. Battery Electric Vehicle scheme.

2. Internal Combustion (IC) Engine or Plug in Hybrid Electric Vehicle (PHEV) Hybrid EV means that the vehicle utilize another type of power source, apart from the electrical power. The most common combination is the combination between EV (motor and battery) and IC (generator).

There are two main type of hybrid EV based on it arrangements [1]. Firstly, parallel hybrid and series hybrid, which can be seen in the figure 2.

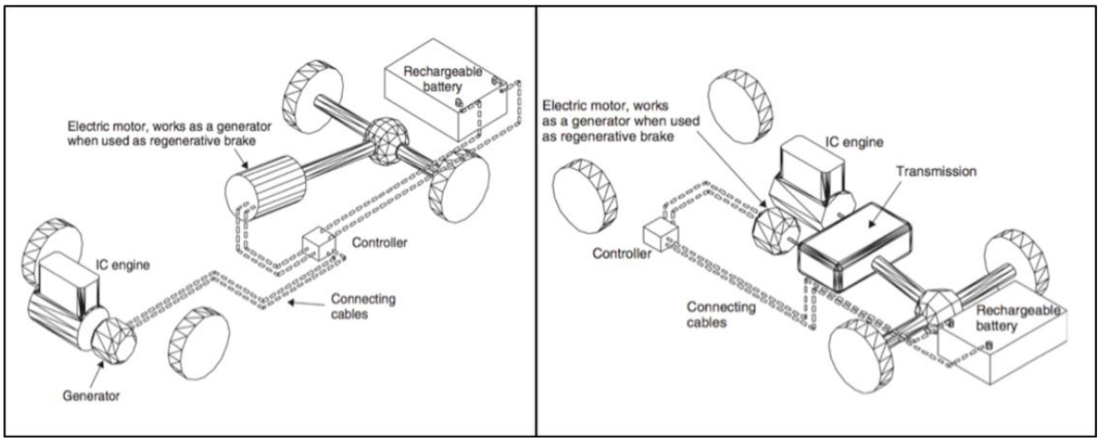


Figure 2. a. Series IC EV layout; b. Parallel IC EV layout.

3. Fuelled EVs

This type of EV is quite similar with the BEVs in term of structure, except this type of EV used fuel cell instead of rechargeable battery as the source of energy [1]. However, the fuel cell EV is not commonly used at the moment due to high price associated with the infrastructure of hydrogen gas station [2] and high manufacturing cost [3]. The layout of the Fuelled EVs can be seen in the figure 3.

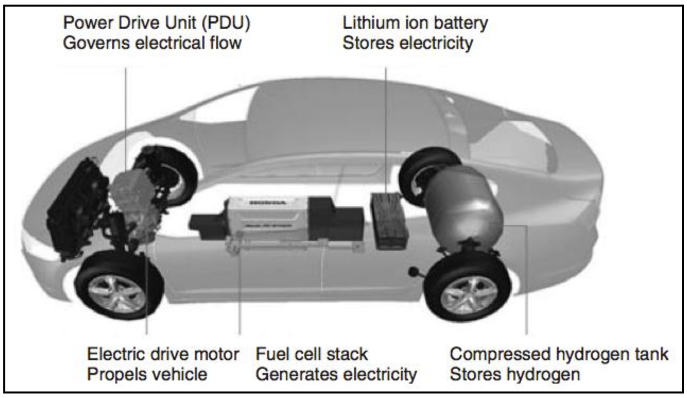


Figure 3. The arrangement of fuelled EV.

4. EVs using supply lines

The example of this type of EV is tram and trolley bus. The electricity is supplied to the EV through the overhead lines and battery [1].

5. EVs which use Flywheels

Basically the EVs using the flywheel are a tram, which its electric motor uses to speed up flywheel. The working mechanism of Flywheel EV is the Flywheel energized during the tram stop while loading the passenger on the tram station. Parry John from Britain was one of engineer who proposed this type of EV [1].

6. Solar-Powered Vehicle

Solar powered EV uses the solar panel, which wrapped on the surface of the car that usually works as the secondary power source. Solar-powered vehicle is considered impractical for daily commute, especially if it acts as the primary power source. Solar car only works effectively in the environment, which has high sun irradiation such as the Darwin and Adelaide [1]. A battery pack also used in the solar car to store the excess of the sun energy.

7. Vehicle using linear motor

The linear motor has the stator and rotor unrolled. The torque generates the linear motion because of the force along its length [1]. One of the important achievements of the utilization of linear motor in the transportation system is “the transport system using magnetic suspension and propulsion” or known as “maglev” [4].

All in all, the most general EV form that available to the mass market is either the using pure battery (BEV) or plug-in hybrid electric vehicle (PHEV). This two types vehicle will be the main consideration of the discussion in the following two chapters, Grid to EV and EV to Grid.

3. GRID TO VEHICLE

3.1 EV Charging Method and Charging Scheme

3.1.1 Charging Method

The life of EV batteries highly depends on how the battery is treated in term of charging or discharging. In addition, the proper charging method will ensure the performance and safety factor of the EV. In general, there are three charging method of EV, Constant voltage, constant current and combination of both of the methods [5, 6].

1. Constant Voltage

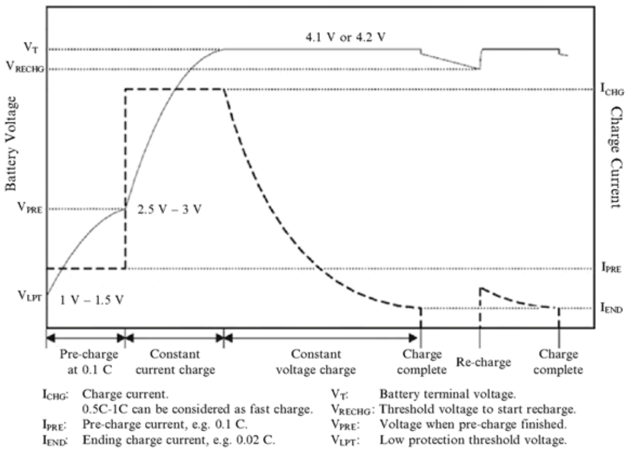
In this method of charging the output of battery charger is maintained at the same level throughout the charging process. However, the battery charging current is varied. The current flow is high during the start of charging and reduces progressively to zero when the battery in full capacity. This type of charging method requires relatively high power during the initial charging which usually not available in the residential charging station.

2. Constant Currents

The charging current is maintained at the same level throughout the charging process by controlling the charging voltage. The drawback of this method is determining the status of fully charged battery, which usually achieved by monitoring the temperature rise, temperature gradient rise, charging period and the change in the voltage.

3. Combination

At the starting period of charging, normally the constant current method is used to achieve fast charging period. When the battery reach certain voltage level, then the method of charging is changed to constant voltage charging.
In EV, the battery must be able to deal with random charging method. Figure 4 shows a typical Li-on battery charging profile.



3.1.2 Charging Scheme

The infrastructure of charging station is one of the crucial factors in EVs integration success. In-house and office charging station is considered as the primary charging station. The various standard of electric vehicle charging also has been made to guide the EV charging scheme. The EV standard is shown on the table 1 [5].

Table 1. Electric Vehicle Charging Standard. Modified from [5].

Standard	Title/Description
National Electric Code	Electric Vehicle Charging System
SAE J2293	Energy Transfer System for Electric vehicles
SAE J2836	Recommended Practice for Communication between Plug-in EV and Utility Grid
SAE J1772	Electric Vehicle Conductive Charge Coupler
SAE J1773	Electric Vehicle Inductively Coupled Charging
IEC 62196	Plugs, Socket Outlets, Vehicle Coupler and EV Inlets-Conductive Charging of EV
IEEE 1547.3	Interconnecting Distributed Resources with Electric Power System

The grid also takes the charging power level into important consideration. According to [5] the are three level of EV charging power.

1. Level 1

The typical charging power in level 1 charging scheme is range from 1.5 to 3 kW. This charging level usually suits to in-house charging station.

2. Level 2

This charging scheme range from 10kW to 20kW

3. Level 3

Level 3 charging is specifically design for fast charging station. With this type of charging the EV can travel up to 300 km in just one hour charging. The level 3 charging power is above 40 km and therefore, is not suitable for in-house charging station.
A typical EV charging scheme is shown is figure 5.

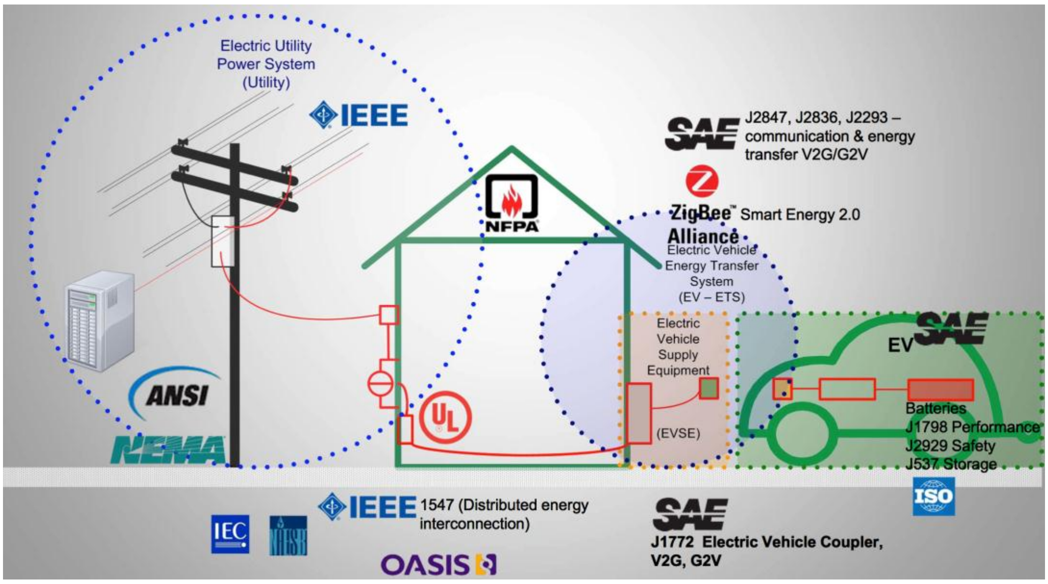


Figure 5. A typical Electric Vehicle Charging Scheme in the smart grid [7].

3.2 The Impact Of EV on the System Demand

3.3.1 Identification of EV Load profile

In order to understand and estimate the EV Load profile on the grid, it is important to understand some parameters that related to the EV, charging technologies and some patterns. The more complex parameters about EV demand identification is discussed in the following part [5].

EV Penetration Level.
EV penetration level is directly proportional to the EV sales. Then, EV sales are the important key to have good forecasting about the future EV demand.

Classification of EV
Each type of EV that already presented in the chapter one has specific characteristic of performance. For example the pure battery vehicle will totally depend on the grid and the hybrid EV has another option of power source

Day-to-day travel distance
The day-to-day travel distance depends on the purpose of the vehicle and the time use of the vehicle i.e. weekend or weekdays.

Battery Consumption and required charging period
Different types of electric vehicle also use different type of battery. Each type of battery has

its own unique power transfer capability and charging time. In addition the weight of the battery also must influence the overall EV performance.

Availability of Charging

At least there are three types of availability of charging scenario that can be simulated:

1. Charging after last trip (in-house charging). This scenario assumed that in the initial stage of EV penetration, the charging station infrastructure is very limited. Therefore, Most of the EV owners just charge the car in their home
2. Charging in public or private charging station. This scenario assumes that the charging station infrastructure already is sufficient. Hence, it will be difficult to estimate what is the level of home charging or public charging. In order to understand this scenario [5] introduced different charging pattern.
3. Charging when the battery level is less than the required level.
   In the urban area where the daily travel distance is less than 30 km, the need of fully charged the EV is not necessary. The owner will only plug the charging when the battery level is less than the minimum point level, which usually at 40%.

Charging Station Technologies

In general there are three types of charging mode that widely used according to the IEC 62196 and IEC 61851 standard. The three modes of charging are summarized in the table 2.

Table 2. Percentage of available charging infrastructure for each EV type .

Type		Charging Infrastructure		
Battery	Vehicle	Mode 1	Mode 2	Mode 3
L7e	BEV	90	10	0
M1	BEV	85	10	5
	PHEV	85	10	5
N1	BEV	85	10	5
	PHEV	85	10	5
N2	BEV	0	80	20

Charging Strategy

The charging strategies is categorized into 3 main part, presented by [5] as follows:

1. Dumb Charging
   Dumb charging is referred to unplanned charging. The owner will always charge the vehicle every the last trip irrespective to the battery level or the electricity price
2. Multiple Tariff charging and smart charging strategy
   This type of charging is provided by the market to shift the EV charging demand to the off peak period. This strategy achieved by giving the setting of the low price signal to the consumer at off-peak period. Smart charging creates the valley filling effect. Another important consideration is the utility must properly determine the peak and off-peak price level. By doing so the system peak could be reduce irrespective to the level of penetration, season, and charging scheme of EVs [8].

3.3 Examples Of EV integration Project

The example of the integration of EV integration project has been examined by author in [9] report 3 assignment 5. The report highlights several countries such as Australia, Canada and Norway that have already implemented the EV trial test. From the study that the author conducted from [10-12] there are a lot of lessons learn that can be taken. Some of the important lessons learn that can be taken from the EV integration project are the sufficient supporting infrastructure such as public or private charging station is an important key in the Grid to EV integration project. Another important lesson learn is the support of various and cross-functional institution especially the media is quite important in order to help the PEVs campaign to the people [9].

4. VEHICLE-TO-GRID (V2G)

V2G is the new technological breakthrough that allows the electric vehicle to transfer its excess of energy back to the grid through some devices. V2G concept defined by [13] as "a system in which there is capability of controllable, bi-directional electrical energy flow between a vehicle and the electrical grid. The V2G technology mainly support by rapid development in power electronic technology. In addition, the cumulative power light fleet vehicle reported to be the largest energy conversion system in the world. For Example in US, the cumulative energy conversion that done through light fleet vehicle accounted for 19.5 TW that 24 times larger than the total of all its electric power generation [14]. According to [15] the concept of V2G is not relatively new. The use of battery vehicle to power up some residential devices such as, refrigerator and lighting, especially during the extreme blackout condition due to the natural disaster. For example, Nissan in 2011 stated that they would design the NissanLeaf to be able to handle bidirectional energy transfer.

However, the concept of V2G has more great potential rather than only operate in such emergency or extreme condition. V2G can be seen as the economic opportunity and help the operation of the utility. The opportunities of contributing to the grid is very potential to the EV since most of the cars are parked for more than 90% of time [16]. A study in [16] conclude that the EV owner could get paid by the utilities for about $4000 yearly to provide the service. Electric vehicle then seen as the electrical devices have multiple benefits to environment, utilities and the owners.

4.1 The motivation of the V2G implementation

The implementation of V2G is the fruits of motivation from cross-functional stakeholder in the V2G area. At least there are eight stakeholders that directly related to the V2G implementation an win the concept to be implemented [13]. Those parties are Utilities, Aggregator service provider, Business/Homeowner, EV Spare-parts Company, EV owner motivation, Vehicle original equipment manufacturer, Vehicle's Battery Manufacture Company, government and including the department of defends. However, the utility and aggregator share the biggest interest in V2G implementation.

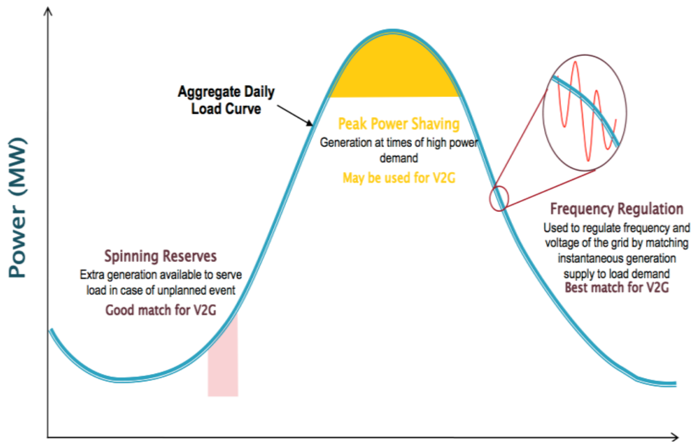


Figure 6. Vehicle-to-grid ancillary services opportunities [18].

The utility sees the V2G system as mobile medium energy storage and “load- levelling” sink to the irregular renewable energy generation. The Utility also sees the V2G system can provide the network support or ancillary services as shown in figure 6. The potential service that could be provide by V2G system would decrease the utility company capital cost of constructing new power plant and the network infrastructure [13, 17].

The V2G system could potentially support the concept of “Markets 3.0: Integrating the Demand Side [17]” with V2G the market 3.0 makes the power system gain more high system flexibility supporting large penetration of intermittent distributed energy resources (DER) to the system operation. By supporting the intermittency of DER, DR could potentially reduce the number of old conventional plants, which relatively expensive compared to DR especially in US market.

Aggregator also plays very important role in the V2G system. A single V2G unit couldn’t give any impact to the grid. In order to participate to the grid operation the V2G must have certain defined minimum power limit storage capacity. Here, the aggregator manages the V2G participants to provide the service as the single point of contact seen by the grid. The aggregator enrols and accumulated the participant and then reconciles the payment.

4.2 V2G operation and functionality

4.2.1 Vehicle-to-Grid Equipment

In general, transferring the energy from the vehicle to the grid is achieved through the same means when charging the EV. However, there are some important configurations and extra features that must had by those means to successfully and safely transfer the energy from the Electric vehicle to the grid. The general schematic diagram of the V2G concept is shown in figure 7. The study in [13] explained four important parameters in V2G supply equipment. Those four concepts describe as follows:

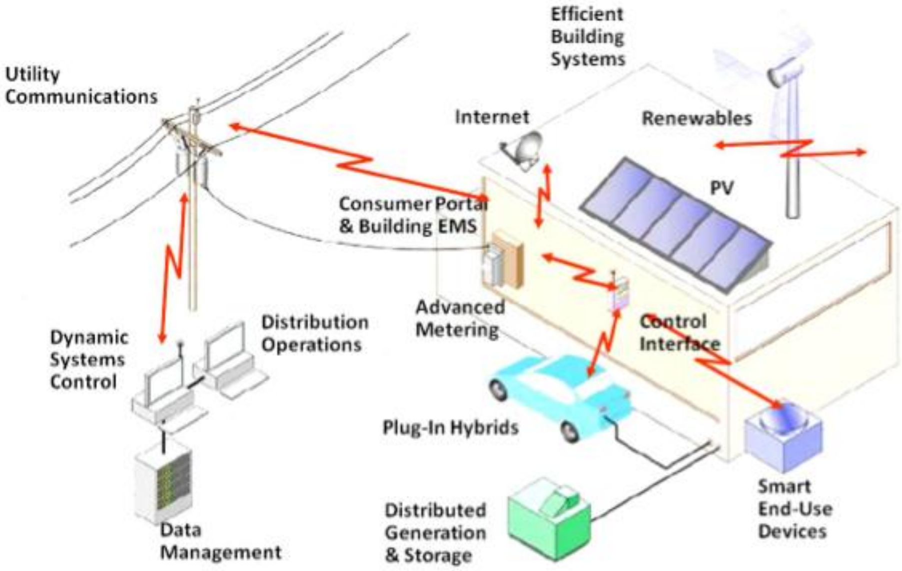


Figure 7. V2G energy flow diagram in the smart grid context [13].

Vehicle to grid premise equipment

The V2G systems are almost similar with the grid-tie generation. Whether the EV supply equipment is AC or DC, it treated the similar to the PV system. The V2G system is also imposed by the requirement IEEE 1547 Standard that must have AC synchronization of the distributed energy resources. The only thing that make the V2G system different to other DER is that the EV supply equipment has bidirectional power transfer capability that make the V2G can drawn the power from the grid. The vehicle provides the EV supplies equipment; Communication and control system give the signal to the means which direction the power must flow [13].Vehicle to home or vehicle to building premise equipment. Vehicle to home (V2H) or vehicle to Building (V2B) is more simple and easier to control compare to the V2G. The reverse power interface with the local grid is not needed [13]. However, unintentional islanding system must be taken into the consideration to guarantee the safety factor.

Islanding

The safety factor of V2G islanding operation is a crucial issue. Islanding in the V2G is the condition where the V2G system keep supply the power to the grid even the main source of the power is out. This condition will harm the vehicle, and disturb it main function as the mean of transportation. Hence the V2G supply equipment must be equipped with anti islanding control scheme.

4.2.2 On-board vehicle equipment

The on-board EV supply equipment (EVSE) comprise of three main components: Plug-in EV inlet, on-board charger, and the energy storage system (battery). There are two mode of operation regarding the voltage output of the EVSE AC or DC.

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Alternating Current

If the EVSE is working on AC state when charging the EV, the output power that transfers back to the grid through the EVSE inlet is in AC form; hence the inverter is on-boarded in the vehicle. The schematic diagram of AC EVSE is shown on the figure 8.

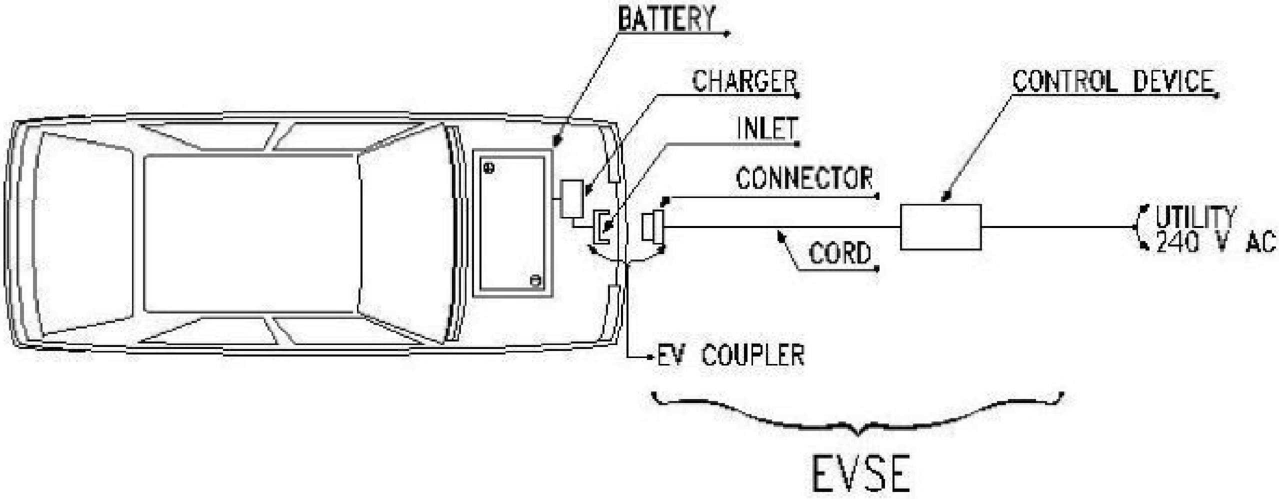

Figure 8. AC charging and Discharging Schematic [13].

Direct Current

If the EVSE output is DC when charging the EV, the output power that transfers back to the grid through the EVSE inlet is in DC form; hence the off-board inverter is needed to convert the EVSE output from DC to AC. The schematic diagram of DC EVSE is shown on the figure 9.

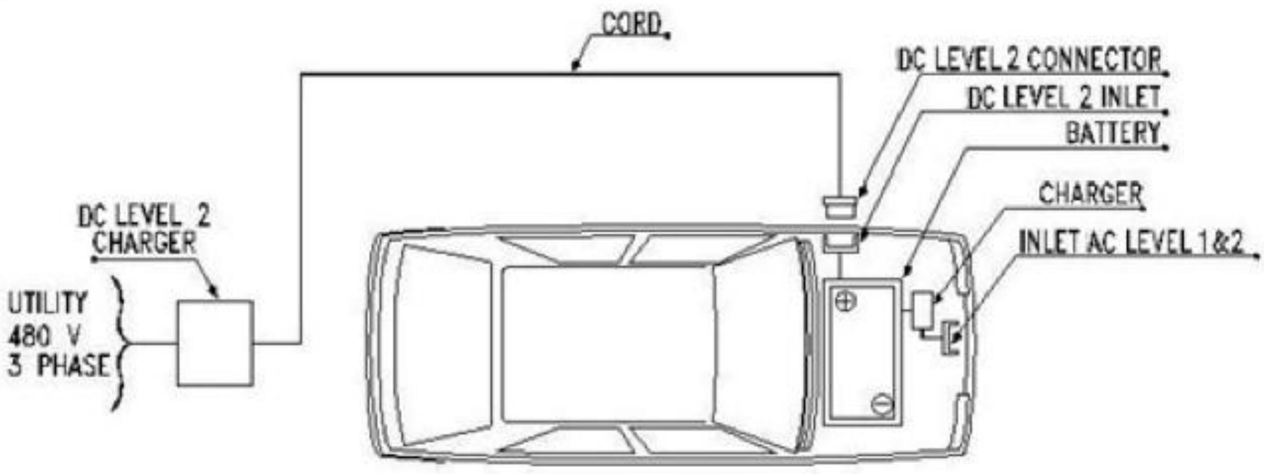

Figure 9. DC charging and discharging schematic [13].

4.2.3 Vehicle to grid communication in the Smart grid

The typical communication path of the V2G system is best summed-up in the figure 9. The report in [13] explained that the V2G communication system in the smart grid require low latency, common protocol and high reliability. Therefore it subdivided into several segment as shown in figure 10.

	UTILITY/INDEPENDENT SYSTEM OPERATOR	AGGREGATOR/ ELECTRIC VEHICLE SUPPLY EQUIPMENT	ELECTRIC VEHICLE SUPPLY EQUIPMENT	ELEVTRIC VEHICLE / BATTERY MANAGEMENT SYSTEM
SEND	• Reg up/down signals • Market pricing • Capacity pmt.	• EVSE control signal • Performance stats. • Participant pmt	• Proportional chg signal. • Resp. verification • Metered data	• Battery SOC • Chg/dischg auth • Battery capacity
RECEIVE	• Verified aggr. Ctrl response • Grid bal. signals	• ISO/RTP signal • Verified EVSE ctrl response • User optout cmd • Market payments	• Aggregator ctrl signal • User preference programming input	• EVSE charge control signal

Figure 10. The communication path of V2G system in the smart grid [13].

4.3 V2G implementation issues

It is important to identify the barrier of V2G implementation before it widely used. Hence, it can ease transition phase from EV to V2G. Most of the people believed that the main issue is related to technical stuffs. However, when barrier identified one by one it is found that untechnical stuffs such as government and social acceptance of the technology give significance contribution to the V2G implementation barrier. The study in [13] comprehensively categorized the barrier into seven varieties of barrier.

The first implementation issue is come from the “stakeholder”. In the first part of this chapter, it is explained that the motivation is come from the stakeholder. However, at the same time a few stakeholders also pose some barrier to the V2G implementation. To the utility the V2G is seen as the burden to them in implementing the new sophisticated technologies and business model. V2G require non-conventional interoperability obligation, rapidly changing standard, and low latency network communication. In addition, non-technical issue such as lack of offered capital investment, uncertain grid reliability, accountability and prices for the future market worsen the problem [13].

To Automotive industry also experienced the financial problem in implementing V2G due the industry is highly competitive in the market. High capital investment is needed in to get V2G technology matured and well accepted in the market. In V2G technology; the battery will be charge and discharge quite frequently, which add to uncertainty of battery performance and lifecycle. To some EV owner, the V2G operation gives uncertainty of battery lifecycle, vehicle performance and the complexity of vehicle operation. To overcome this barrier, the costumer must be educated first. The media can be used as the tool to educate the costumer while advertise the product [13].

The proper “Test and Evaluation” in V2G is not done yet, either by the industry or the academic, this make the V2G is merely a theoretical advanced rather than the practical advance. In order to carry out the V2G test, there are three important areas that come to the first place. Firstly, test to see impact of operation to the vehicle’s battery, the implication to the distribution network and lastly the system reaction. Each of area has their relative importance to different main stakeholder (Utility, EV Owner, Regulators and Market). The test and evaluation must be properly carried out to assist in decision making of regulators [13].

The third barrier is comes from the “immaturity of the aggregator service model”.
According to [13] at least there are three main elements that must be taken into serious consideration in operating EV as a load and V2G as the source. (1) The complexity power electronic devices in managing the power in or out. The control algorithm must be really well design and integrated to the power electronic devices. (2) “The EV battery can perform as a network or building-connected power source (i.e., “negative” load, as opposed to merely an adjustment or shedding of “positive” load)”[13]. (3) The network sees the EV battery as the balancing resources that can inject and receive power. Due to the all elements mention above is not clearly defined, the aggregator cannot design standard service model [13].

“Low Risk tolerance” of EV devices that has been designed by the EV manufacturing company also poses contribute to the V2G implementation problem. This is because most of the vehicle battery main function is not to be discharged by other means except the one that already on-board with the vehicle control system. The current inadequate “charging infrastructure and billing system” also create barrier to the implementation of V2G technology. Therefore, in the following section some pilot project will focus on the charging and discharging station infrastructure and adequate billing system to properly give the incentive to V2G participants [13].

The employment of V2G technology requires “Expense of Adjacent Smart grid control technology”. The level of expense is depending on where the V2G is applied. The area with intensive utilization of smart grid enabling technology such as Advance Metering Infrastructure (AMI), Home Area Network (HAN) and EV supply equipment will require less installation expenses which range around $2,500 to $7,000. These expenses also can be seen as a barrier to implementing the V2G technology, especially the area with low utilization of smart grid equipment. Lastly, “lack of strong government policy directive, standard and market support” [13].

4.4 V2G pilot project and future development in several country

With all the prominent that V2G technology has, its implementation is still in early pilot project state and the market for this technology is still far down away. This part of the report highlights several pilot project of V2G technology that has been implemented across the globe [13]. North America ECOtality program use Toyota Prius with 25 kW grid-tied DC chargers to demonstrate V2G capability to support peak demand in one particular building. The impact to load and the battery is also studied. This pilot project objective is to get the good understanding about the bidirectional charging performance. Nuvve V2G pilot project in Denmark specifically design a server that connect the grid to the costumer EV. The objective is to operate the V2G process trough the server as a short-term participation in frequency stabilisation [13].

Italy also has its leading program so called “E-moving”. The program uses the Kangoo and Renault Fluence to examine the V2G technology, charging resources, impact to the distribution system and the vehicle’s battery. Another leading country in EV is Germany launch its V2G pilot Project “Meregio Mobil” in July 2009. The pilot project set six objectives of the project. The goals are to analysing the intelligent control of load charging and energy transfer back to the grid; establishing up to 600 point of the charging and discharging infrastructure; design the billing management system and else. The ultimate objective of the program is to have one million V2G available in Germany at the end of 2020. The others leading pilot project are: Rechargelt in Google’s campus, SmartGridCity in Colorado, Austin Energy and V2Green in West Texas and many more [13].

For the Future plan the USA forecasted to have one million electric vehicles at the end of 2019 which equivalent to160 new power plant that need to build. The current preparation to equipped the estimated EV with the V2G capability, the University of Delaware will prepare 100 EV that have V2G capability at the end of 2011.

The european countries such as Denmark targeted to have 10% of its vehicle equipped with the V2G capabilities. They expected the market value about $380 million at the end of 2020. Japan as the leading in electric vehicle industry will have the charging infrastructure grow from %118.6 million to $1.2 Billion from 2015-2020. It was the Nissan that has already plans to equipped one of its product with the V2G capability [13]. With 24kWh battery power, the Nissan Leaf could power up average residential houses for two days. Nissan Leaf is set as the reference to other additional market in order to appropriately complete the adjustments from EV to V2G. The more complex picture about the future V2G development can be seen in the figure 11 where three countries, USA, Japan, and China has the biggest V2G market share.

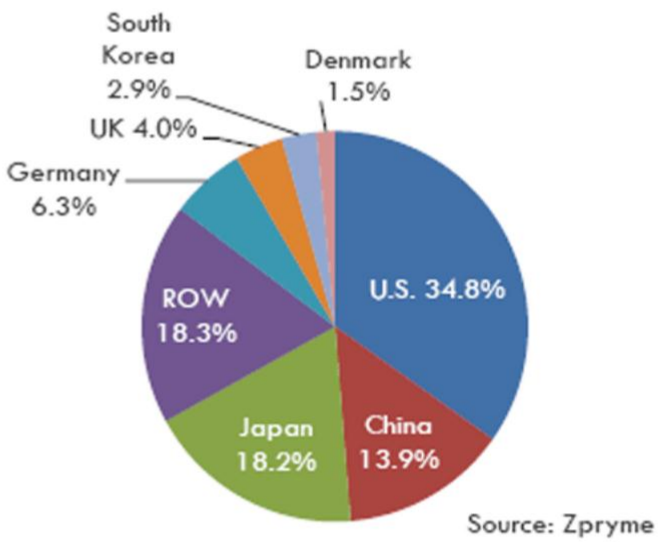

Figure 11. V2G market segmentation by country in 2015 [19]

However, the number presented above is just merely a target, while the more realistic value is seemed to be far behind. According to the report from Pike Research [20] it will be less than 100,000 EV that have V2G capability at the end of 2017. This condition is caused by many reasons such as technology immature, stakeholder participation, aggregator and poor support

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from policy and regulatory [13]. In addition to that, there are a lot of scepticisms about the concept; people believed the implementation on V2G will not realized in the near future.

5. CONCLUSIONS

The discussion above can be concluded into five concise following points:

1. There are a lot of types of electric vehicle that available in the market. Understanding each types of EV are important due to it has different operational characteristic and implication. However, the most common type is Battery Electric Vehicle and Plug-in Hybrid vehicle. Hence, most of the study including this report is only considering those two types.
2. Introducing the EV to the system demand will create some operational issue both to the utility and the consumer, hence it is important to understand its behaviour such as charging scheme, charging method, charging strategy and identify the EV load demand. Understanding the key operation of electric vehicle will reduce the negative impact that creates by EV to the system demand and network.
3. The Development and the maturity of Electric Vehicle and the Smart Grid Concept birth the concept of Vehicle-to-Grid (V2G), which allow the EV to transfer back the power to the grid and contribute to the electricity market operation.
4. Due to its newness technology, V2G is still encounter with relatively many technical and non- technical barriers. This technical barrier is important to understand and examined in order to help V2G transition and integration process.
5. Currently, the implementation of V2G is still in the pilot project phases, that mainly done in USA, Germany, Denmark, Japan and China, with only hundreds of Vehicle that already on the road.

REFERENCES

[1] J. Larminie and L. James, Electric Vehicle Technology Explained, 2nd ed.. ed. Hoboken: Hoboken : Wiley, 2012.

[2] Y. Sakamoto, N. Hoshi, S. Murooka, C. Meifen, A. Yoshizaki, and K. Hirata, "Basic study on fuel-cell-hybrid-electric-vehicl fueled by sodium borohydride," in Power Electronics Conference (IPEC), 2010 International, 2010, pp. 814-819.

[3] H. Xiaolai, T. Maxwell, and M. E. Parten, "Development of a Hybrid Electric Vehicle With a Hydrogen-Fueled IC Engine," Vehicular Technology, IEEE Transactions on, vol. 55, pp.1693-1703, 2006.

[4] R. Thornton, M. T. Thompson, B. M. Perreault, and F. Jiarong, "Linear Motor Powered Transportation [Scanning the Issue]," Proceedings of the IEEE, vol. 97, pp. 1754-1757, 2009.

5] R. Garcia-Valle and G.-V. Rodrigo, Electric Vehicle Integration into Modern Power Networks. Dordrecht: Dordrecht : Springer, 2012.

[6] S. Dhameja, Electric Vehicle Battery Systems. Melbourne: Newnes, 2001.

[7] P. John, "SAE Ground Vehicle Standard Smart Grid," ed, July 2010.

[8] S. Shengnan, Z. Tianshu, M. Pipattanasomporn, and S. Rahman, "Impact of TOU rates on distribution load shapes in a smart grid with PHEV penetration," in Transmission and Distribution Conference and Exposition, 2010 IEEE PES, 2010, pp. 1-6.

[9] Fathurrahamn, "The main implications of Electric Vehicle load growth in the distribution network and examples from worldwide trials in the field and, their main targets and lessons learned.," Schoool of Electrical Engineering and Telecommunication UNSW2014.

[10] T. Mader and T. Braunl, "Western Australia Electric Vehicle Trial," Western Australia2012.

[11] "Demonstrating Electric Vehicle in Canada," Electric Mobil Canada (EMC), National Centre for Advanced Transportation (CNTA) Natural Resource Canada (NRCan), Canada March

2010.
[12] J. Järvinen, F. Orton, T. Nelson, J. Järvinen, F. Orton, and T. Nelson, "Electric Vehicles in Australia's National Electricity Market: Energy Market and Policy Implications," The Electricity Journal, vol. 25, pp. 63-87, 2012.
[13] A. Briones, J. Francfort, P. Heitmann, M. Schey, S. Schey, and J. Smart, "Vehicle-to-Grid (V2G) Power Flow Regulations and Building Codes Review by the AVTA," The INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance, IdahoSeptember 2010.
[14] W. Kempton and J. Tomić, "Vehicle-to-grid power implementation: From stabilizing the grid to supporting large-scale renewable energy," Journal of Power Sources, vol. 144, pp. 280-294, 6/1/ 2005.
[15] Vehicle-to-Grid. (June 2012, Russell Lefevre. Available: http://green.tmcnet.com/topics/green/articles/2012/06/29/297011-vehicle-to-grid.htm
[16] U. o. Delaware. (December 2007, Car Prototype Generates Electricity, And Cash. Available: http://www.sciencedaily.com/releases/2007/12/071203133532.htm
[17] R. Masiello. (June 2013) Markets 3.0: Integrating the Demand Side. IEEE Smart Grid.
[18] C. Gorguinpour. (2012, DoD Plug-In Electric Vehicle Program. Available: http://www.electricdrive.org/index.php?=a/GetDocumentAction/id/40793
[19] Environmental_Leader. (January 2010, Global V2G Market to Reach $26.6 B by 2020. Available: http://www.environmentalleader.com/2010/07/20/global-v2g-market-to-reach-26- 6-b-by-2020/?graph=full&id=1
[20] K. Fehrenbacher. (November 2011, Vehicle-to-grid tech to connect only 100K cars by 2017. Available: http://gigaom.com/2011/11/21/vehicle-to-grid-tech-to-connect-only-100k-cars by-2017/